Caliola Engineering, LLC
Technical Exhibit:
Application for FCC Special Temporary Authority (STA)

Caliola Engineering, LLC is applying for a new FCC Special Temporary Authority (STA) license in support of their Small Business Innovation & Research (SBIR) Phase II effort with the Air Force Research Laboratory Information Directorate (AFRL/RI) in Rome, NY, contract number FA8750-20-C-1525. Caliola will be testing HF data link communication between Denver, CO and Colorado Springs, CO.

Background

The Air Force's ability to offer survivable voice and data connectivity worldwide in the absence of satellite communications (SATCOM) is severely constrained. Space is an increasingly contested and competitive environment. In this SBIR, Caliola in collaboration with AFRL is developing an innovative, multicarrier wideband High Frequency (WBHF) data link that will form the foundation of a mesh network that could be deployed at scale as a dependable SATCOM failover. To demonstrate the WBHF capability as a reliable high throughput data link, we have designed a multicarrier communication protocol and algorithms and implemented the design using Software Defined Radio (SDR) platform with commercial off-the-shelf (COTS) RF front-end and antennas.

Near Vertical Incident Skywave (NVIS) HF over-the-horizon communication test will be used to validate results obtained from our extensive modeling and simulation (M&S) and bench test and demonstrate WBHF data link performance in ionospheric channel.

Objective

The goal of the over-the-horizon field test is to validate the wideband multicarrier HF waveform performance in actual ionospheric channel against M&S prediction and bench test measured data. We will perform wideband HF filed test using representative set of waveform configurations covering possible link budget, range, and sunspot time to validate the multicarrier data link spectral efficiency.

One of the primary features of our waveform design to be validated is its capability to adapt to channel environment by dynamically selecting optimal mode for reliable operation and as such,

the instantaneous channel bandwidth and the multicarrier operational frequency will vary according to the system configuration within the available range of coding, modulation, and frequency.

The transmitted multicarrier signal will occupy at most 24 kHz instantaneous bandwidth potentially non-contiguously across a configurable set of (1 – 8) carriers each with signal bandwidth ranging of 3 kHz or 6 kHz (e.g., 8 × 3 kHz or 4 x 6 kHz). The carriers will be spread across a maximum 400 kHz band.

The operational High Frequency (HF) band will be between 6 MHz and 12 MHz from the locations in Colorado Springs, CO for 90 days from May 23, 2022, to August 26, 2022. (Note: Our wideband multi-carrier system is power and frequency agile. We plan to observe local and remote spectrum occupancy and transmit on the least likely occupied sub-channels with minimum power to satisfy performance requirements to minimize potential interference.) We will also perform ionospheric sounding for channel characterization using similar interference avoidance procedures.

The requested frequencies and transmission operational parameters are those permitted under Section 90.266 of the Commission's Rules, Long Distance Communications on Frequencies below 25 MHz and are identified specifically in the FCC's Electronic Code of Federal Regulations, Title 47 (Telecommunication), Volume 1, Chapter 1, Part 2.106 Table of Frequency Allocations. These frequencies bands requested are designed to avoid the Restricted Bands of Operation outlines in the Electronic Code of Federal Regulations, Title 47 (Telecommunication), Part 15 (Radio Frequency Devices), Subpart C Intentional Radiators.

Listed in the following Table (1a) are the requested proposed technical parameters for this Small Business Innovation & Research program.

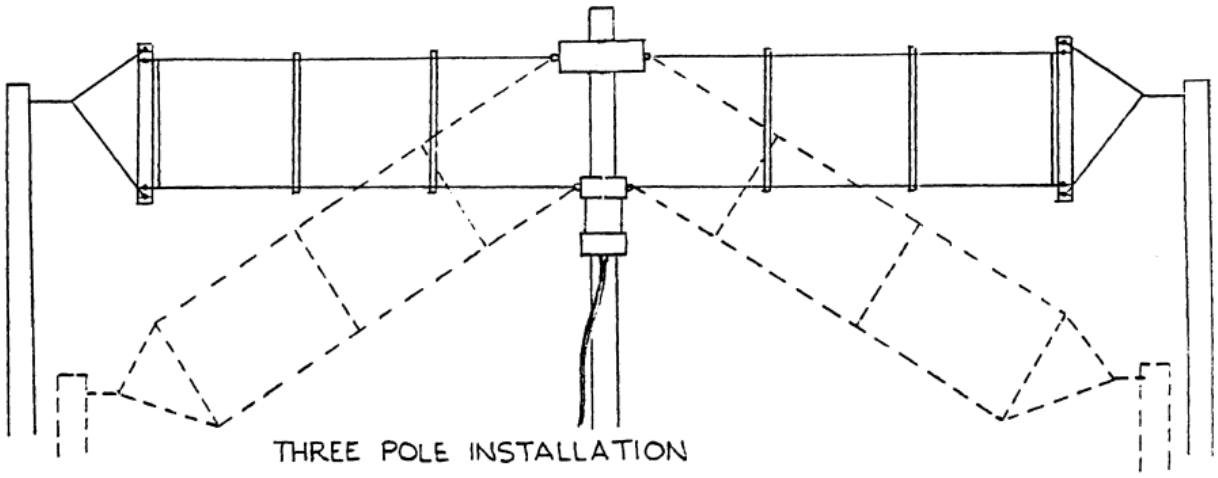
Transmit Antenna	
Transmit Site Locations	**Transmitter Site #1**
	4750 ramblewood Dr.
	Colorado Springs, CO 80920
	38° 56' 37.2" N, - 104° 44' 43.9" W
	Antennal Radiation Center: 28 ft AGL
	Antenna Azimuth Orientation: omnidirectional
	Transmit antenna Vertical Plane orientation: horizontal
	Transmitter Site #2
	1045 Elkton Dr.
	Colorado Springs, CO 80907
	38° 53' 55.8" N, - 104° 50' 40.3" W
	Antennal Radiation Center: 19 ft AGL
	Antenna Azimuth Orientation: omnidirectional
	Transmit antenna Vertical Plane orientation: horizontal

Requested Frequency ranges (MHz)	6.765 - 7.000, 7.400 – 8.1, 9.040 – 9.400, 10.150 – 11.175
Maximum Transmit Power (Site #1)	1 kW peak (average varies between 50 W and 500 W)
Transmitter	Ettus USRP N210 Software Defined Radio
Transmitting Antenna	Caliola built square loop (see Figure 1a)
Maximum Transmit Power (Site #2)	300W peak (average varies between 50 W and 150 W)
Transmitter	Ettus USRP N210 Software Defined Radio
Transmitting Antenna	Dipole from Barker & Williamson Model # BWDS-90N (see Figure 1b)
Maximum Occupied Bandwidth	24 kHz non-contiguous (vary from 3 kHz to 24 kHz).
Maximum Transmit Time Duration (Duty)	Most Experiment will be conducted during the daytime hours during the 3-day period. Active transmissions for 1 – 10 minute intervals, 50% avg duty cycle.

Table 1a. Proposed Transmission Antenna Parameters

The two test site antenna configuration and dimension is shown in Figure 1a and Figure 1b below.

Figure 1a Site #1 Square Loop Antenna (28 ft AGL)



Antenna Installed: INVERTED "V" AS SHOWN IN BROKEN LINES

Figure 1b Site #2 Folded Dipole antenna (19 ft AGL)

The square loop antenna at site #1 is tunable in the HF band with antenna gain of 0 dBi. The antenna at site #2 is located on the rooftop of one-story building at approximate elevation of 14ft with antenna gain of 0 dBi. The shallow inverted "V" raises the antenna radiation center to maximum height of 19 ft.

While Caliola fabricated the antenna used for site #1 and designed the transmit and receive systems, some of the equipment are purchased from commercial vendors. Table 2 shows a list of the commercially purchased equipment that will be used during testing.

Table 2. Commercially purchased transmission equipment list.

Transmitting Equipment			
Manufacturer	**Model Number**	**No. of Units**	**Experimental (Y/N)**
Ettus USRP	N210	2 (2 sites x 1 radio)	N
Electronics & Innovation	A100	1	N
Electronics & Innovation	A150	1	N

This Small Business Innovation & Research Contribution to the Development of the Radio Art

In this SBIR, Caliola is developing an innovative, multicarrier WBHF data link that will form the foundation of a mesh network that could be deployed at scale as a dependable SATCOM failover. Such a network could be deployed, for example, alongside the existing Extremely High Frequency (EHF) SATCOM terminals at Air Force facilities across the Continental United States (CONUS). If satellite connectivity or capacity were to become limited or unavailable, then this mesh network could be used as a backup path for voice calls, strategic messaging, and other data services.

Caliola's work will demonstrate an adaptive and scalable approach to addressing critical communications capability as a reliable SATCOM failover through the application of adaptive multicarrier communication protocol and algorithm design.

If there are any technical questions with the proposed application, please contact one of the undersigned.

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